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THE TREATMENT OF BRAIN ABSCESS *†

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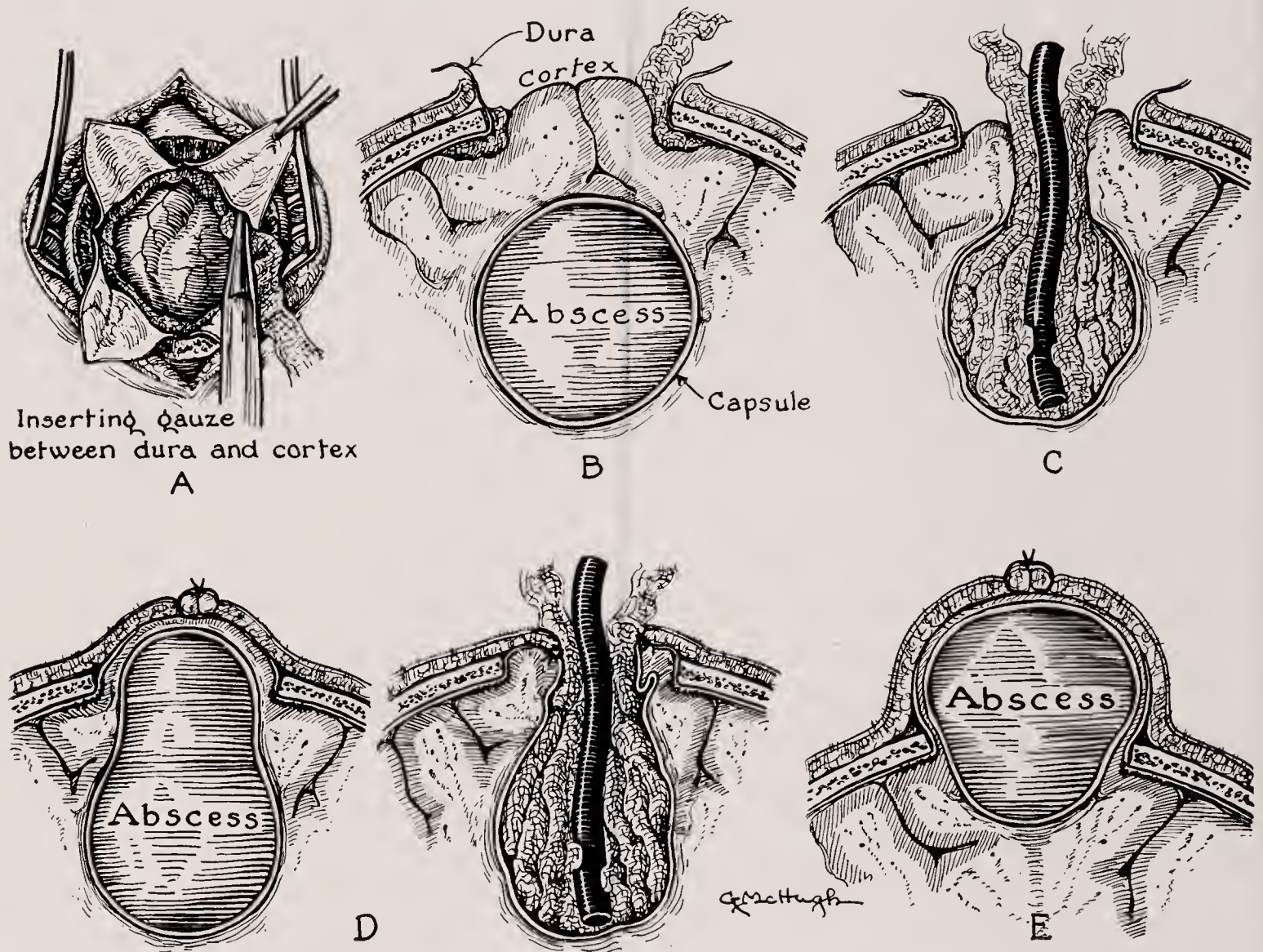
THE most appropriate method of dealing with abscesses of the brain is still the subject of discussion. Any method which has proved reasonably successful merits consideration. The present report is based upon a series of 17 consecutive cases in which the abscess has been dealt with surgically (Table I). Of the 17 cases, four were cerebellar and 13 were cerebral.† Of the former none died. Of the cerebral cases five died (29.4 per cent). In three of these five fatal cases the infection metastasized from the lung. In Case 2, there were multiple areas of infection throughout the body, in the chest, abdomen and pelvis, and a culture of the blood revealed *Staphylococcus aureus*, the organism found in the cerebral abscess. The patient improved greatly following drainage of a large abscess in the right parietal area, only to become unexpectedly stuporous on the eighth postoperative day and die within 24 hours. Knowing the tendency for abscesses which originate by metastasis from the lungs to be multiple, it was believed that death was probably the result of one or more other intracranial abscesses. Unfortunately, necropsy was refused. In Case 3, a child of 18 months, where the infection also arose from the lung, necropsy revealed a total of seven separate, intracerebral abscesses and a leptomeningitis. In Case 5, the child, age 3, was admitted in extremis, and died within less than 24 hours after admission and operation. Necropsy revealed an enormous abscess of the left parieto-occipital region which had ruptured into the lateral ventricle and produced a diffuse leptomeningitis, in all probability prior to the operation. It is difficult to see how any type of treatment could have benefited these three cases (unless in Case 5, a combination of drainage and the administration of sul-

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phanilamide which, however, did not exist at that time, 1932, might have proved effective). The other two fatal cases (Cases 9 and 13) presented entirely different conditions and will be considered in detail later.

Method Employed.—Since 1935, an endeavor has been made to treat all cases by the following method. Occasionally, as in Case 12, circumstances have precluded following this procedure completely or, as in Case 8, have made it unnecessary. No claim is made that the method is either new or original, only that it seems rational and, as will be seen, has been successful.



TWO-STAGE METHOD OF TREATING BRAIN ABSCESES

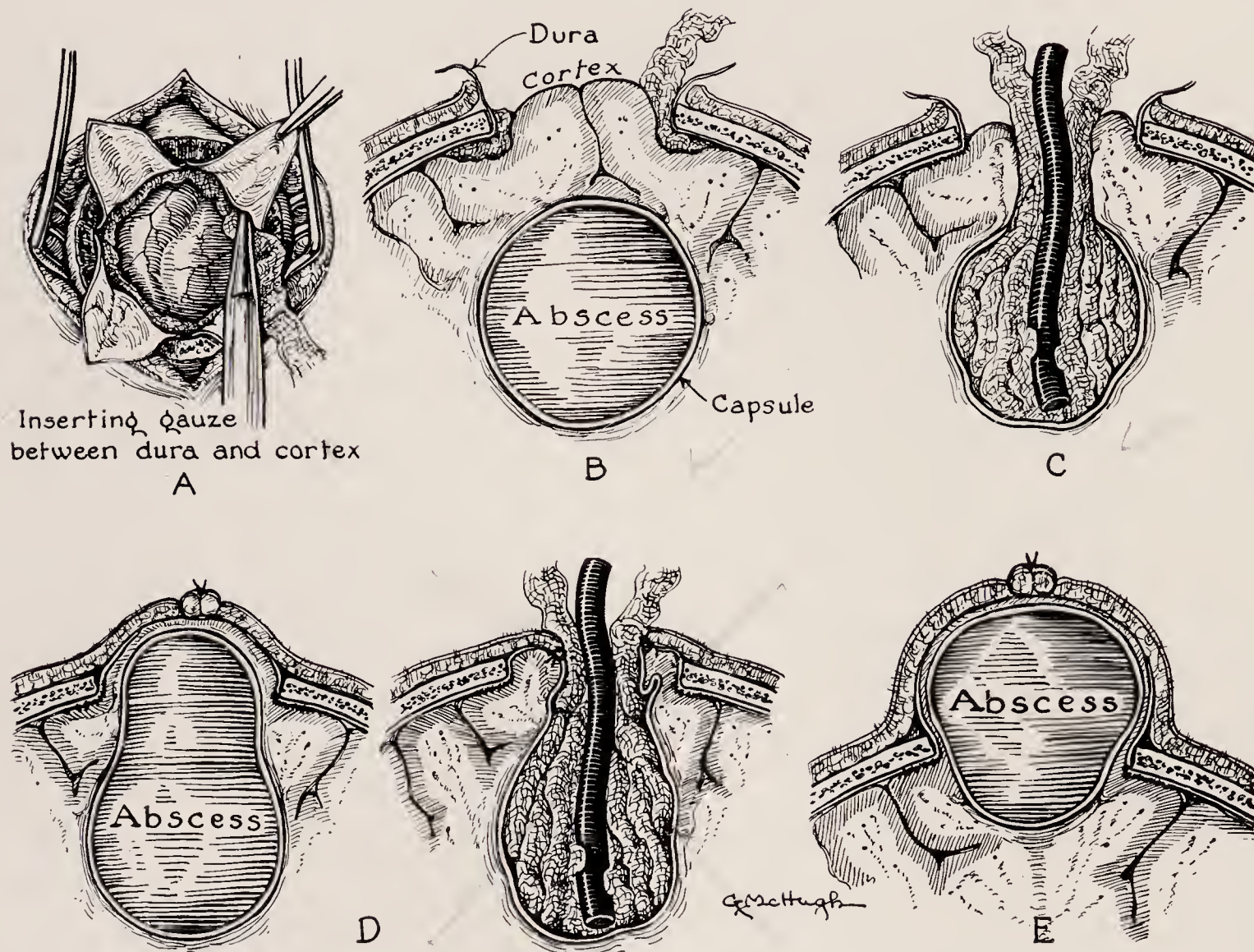
FIG. 1.—First Stage: (A and B) An incision and small craniectomy are made over the abscess. A cruciate incision is made in the dura mater, and the subdural space about the opening is packed with gauze soaked in a weak solution of iodine.

Second Stage: (C) The usual finding at the second operation. The cerebral cortex has been sealed to the dura mater. The cortex overlying the abscess is removed and the abscess is evacuated and drained. (D) When the abscess has partially herniated through the craniectomy it can be marsupialized and drained. (E) Rarely, the abscess will be found to have herniated out of the skull. It can then be removed *in toto*.

First Stage.—The abscess having been localized, an incision is made over it. In the case of a cerebellar abscess of otogenic origin, the incision is a vertical one, made a short distance medial to the mastoid process and the wound of the mastoidectomy; with an otogenic abscess of the temporal lobe, the incision is just in front of the ear. The margins of the incision are separated by a self-retaining retractor. A trephine opening is made in the skull and enlarged with a rongeur to 3 or 4 cm. in diameter. A cruciate incision is made in the dura mater. The resultant triangular flaps of dura mater are

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This method is designed to close off the meningeal spaces, subdural and subarachnoid, from the infectious material escaping from the abscess. It has long been recognized that the tendency for the brain to fall away from the dura as the abscess is evacuated opens these channels and is a great potential source of meningitis, usually a fatal complication. This method which deliberately promotes scar formation between the cerebral cortex, pia-arachnoid membrane and dura mater prevents this. It has been adopted from the thoracic surgeons, who utilize a similar procedure to obliterate the pleural space about the site of drainage of a lung abscess. Its success in the field of thoracic surgery is well known. Although it has been used by other surgeons, as noted by Davidoff,³ the usefulness of the method is not commonly recognized. Some neurosurgeons attempt to wall off these spaces by cauterizing the dura mater and by suturing it to the pia-arachnoid membrane and then draining the abscess at the same operation (Adson and Craig,¹ and Davis⁴). Knowing the insecurity of sutures placed in the pia-arachnoid and the tenuous nature of adhesions produced by the dead coagulum resulting from the electric cautery, this method has been avoided in this clinic. The use of a two stage procedure, but without any mechanical or chemical stimulus to promote obliteration of these spaces, was advocated by Dowman, in 1923,⁵ but not generally accepted.

In only one case have we had an opportunity to examine the meningo-cerebral scar produced by this method. As the case itself is unusual and interesting, it is presented in some detail.

Case 13.—Unit No. 191568: N. A. C., female, age 6, was referred by Dr. J. R. Doty of Gary, Indiana, with the diagnosis of a brain abscess. She was admitted to the University of Chicago Clinics January 24, 1938.

On November 1, 1937, the patient fell while playing, forcing a long dried weed up her right nostril. There was profuse bleeding but no other symptoms at the time. That night she vomited and complained of headache. Subsequently she had repeated episodes of headache and vomiting, which usually occurred in the early morning. The symptoms grew steadily more severe. The child lost weight, her appetite was poor and she became irritable. She was in bed during most of the month of January. There was no fever until January 16, 1938, when she developed a temperature of 103° F.

Some fever was present thereafter. On January 21, 1938, she developed a severe headache, vomiting and a stiff neck which persisted.

Physical Examination.—She was poorly nourished and dehydrated; and, although rather listless and irritable, was fairly cooperative, rational and well oriented. The superficial veins of the scalp in the right frontal region were dilated. There was marked stiffness of the neck. Kernig's sign was positive bilaterally. There was a severe bilateral papilledema with several hemorrhages. The visual fields were full to gross tests. There was a marked lower, left facial weakness. There was questionable slight weakness of the left arm (she was said to be left-handed) but no weakness in the lower extremities and no evidence of an aphasia. Tendon reflexes were active and equal on the two sides. There was a positive Babinski's sign on the left side. The



FIG. 2.—Case 13: Drainage of an abscess in the right frontal lobe. The dura mater is firmly adherent around the margins of the site of drainage. There has been no spread of infection to the neighboring meningeal spaces.

temperature was 37.5° C., pulse 60, and respirations 16. *Diagnosis:* Abscess of the right frontal lobe.

Operation.—First Stage. January 24, 1938: Under local anesthesia, an incision was made in the right frontal region parallel to and just back of the hair line. A trephine opening was enlarged to 3x4 cm. in diameter. The dura was incised and the cerebral cortex, which was under very great tension, herniated through the opening. The subdural space was packed. A brain puncture needle, inserted through the cortex, encountered the abscess at 2.5 cm. Forty-five cubic centimeters of pus were removed. The patient's pulse immediately rose from 60 to 90 per minute. Cultures of the abscess revealed hemolytic *Staphylococcus aureus* and pneumococcus, Type XXIV, for which there is no antiserum.

During the days which followed her pulse varied from 100 to 140, temperature remained about 38° C., respirations 20 to 26. Her condition was good. She ate and took fluids well.

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On January 26, 1938, the subdural pack was removed. Two days later a needle was introduced through the incision into the abscess and 17 cc. of pus were removed. Cultures revealed that the pneumococci now predominated. On the evening of January 29, 1938, the temperature rose to 39° C.

Second Stage.—On January 30, 1938, the wound was reopened. There was considerable infection of the scalp, which was drained. The abscess had herniated through the defect in the bone for a distance of 1.5 cm. The abscess was incised and its contents evacuated. A piece of weed was recovered from within the abscess. The abscess occupied most of the right frontal lobe and measured 7 cm. in diameter. The capsule was sutured to the scalp (Fig. 1 D) and the cavity packed and drained.

Subsequently, she was much improved and the next day her temperature was normal (37° C.) for the first time since her admission. However, that evening at



FIG. 3.—Case 13: Photomicrograph of the point of adhesion of the dura mater to the cerebral cortex. The dura mater is united to the cortex by a firm scar. The defect through which the abscess was drained is at the right. (Perdrau's method.)

6 P.M. her temperature suddenly rose to 40.7° C. The pulse increased from 100 to 164 and she became much more irritable. The wound was examined and seemed all right. There was no drainage of cerebrospinal fluid. A lumbar puncture was made. The fluid was opalescent and contained 4,060 cells which were almost all polymorphonuclear leukocytes. Cultures showed pneumococci. She was given sulphanilamide, fluids were forced and lumbar punctures were made three times daily. The spinal fluid gradually became less purulent but yellow in color, and after February 7, 1938, it was difficult to obtain more than a few cubic centimeters. A block had developed in the spinal subarachnoid space. Beginning February 3, 1938, the number of pneumococci in the spinal fluid began to diminish and by February 5, 1938, cultures of the fluid were sterile. However, her condition grew steadily worse and she died February 10, 1938, ten days after the onset of the pneumococcus meningitis.

Necropsy revealed the abscess in the right frontal lobe. The anteromedial part of the lobe was hemorrhagic and degenerated and very adherent to the cribriform plate on that side. When it was removed a portion of the weed was found projecting through

the cribriform plate from the nose into the cranial cavity. There was no evidence of meningitis over the convexity of the cerebral hemispheres or about the site of drainage of the abscess to the margins of which the dura was firmly adherent (Fig. 2). There was a thick layer of pus covering the hypothalamus, the undersurface of the pons and medulla oblongata. The infection had obviously spread backward from the region of the cribriform plates and not from the point of drainage of the abscess.

Figure 3 is a photomicrograph of the meningocerebral scar at the edge of the defect in the frontal lobe through which the abscess was drained.

Comment.—Although this case terminated unfortunately from a complication which could hardly have been foreseen or prevented, it demonstrates the adequacy of the method for the purpose for which it was designed. The dura was firmly sealed about the site of drainage and this sealing prevented the spread of infection at this point and effectively walled off the meningeal spaces from the infectious material (Figs. 2 and 3).

On one occasion (Case 12) the abscess was situated only 3 or 4 Mm. beneath the cortex. The subdural space was walled off as usual, but on puncturing the abscess with a needle it ruptured into the field, necessitating evacuation and drainage (as will be discussed below) at the initial operation. Although a most satisfactory result was obtained in this case, it is thought that the one stage procedure is too hazardous to warrant general use. In Case 8, the attack upon the intracerebral abscess was preceded by the removal of a focus of osteomyelitis in the skull and the evacuation of a large extradural abscess five months earlier. The two stage procedure was not necessary as this inflammatory process had walled off the subdural space.

If in the interim between the first and second stages signs of pressure develop, the abscess may be punctured and evacuated. In our experience, however, repeated evacuation through a needle will not suffice to cure an abscess which is not sterile. There may rarely occur cases in which repeated evacuation in this manner will not suffice to relieve tension and the delay necessitated by the two stage procedure may prove dangerous. It is believed that this may have been true in the following case.

Case 9.—Unit No. 154484: V. D., female, age 15, was taken ill, April 27, 1936, two months prior to admission, with a sore throat, chill and fever. Five days later pus began to discharge from both ears. Six days after this a right mastoidectomy was performed at another hospital and pus containing hemolytic Streptococci recovered. A week later the left mastoid was opened. The same organism was found. Eight days after this last procedure the patient had a chill, a temperature of 104° F., and Streptococci were recovered from the blood stream. A lumbar puncture performed three days later revealed a "normal" pressure, six cells, and Pandy's test was negative. The following day she developed pain in the left temple and about the left eye. The left mastoidectomy wound was reexplored but nothing unusual was found. The subsequent course was uneventful and she was discharged from the hospital three weeks later. She soon developed headache and began to vomit. These symptoms grew progressively more severe. A lumbar puncture demonstrated an increased pressure, 180 cells per cu. Mm., mostly lymphocytes, and Pandy's test gave a one plus reaction. She was then admitted to the University of Chicago Clinics, five days after discharge from the other

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hospital and two months after the onset of the initial infection, complaining of headache.

Physical Examination.—The patient was mentally clear and alert. There was an early bilateral papilledema. The neck was slightly stiff. There were slight incoordination and weakness of the left arm. Blood pressure, 115/80. The examination was otherwise negative. The following day her headache was severe. Pulse had fallen to 52 per minute and she soon became comatose. A slight left facial weakness could be made out.

Operation.—Nine A.M., June 28, 1936: An incision and trephine opening were made in the right temporal region. The opening was enlarged with a rongeur to between 3 and 4 cm. in diameter. A cruciate incision was made in the dura and the brain herniated through the opening. A strip of gauze saturated with a weakened tincture of iodine was packed into the subdural space about the opening. A brain puncture needle was inserted and encountered the abscess at 2 cm. Ten cubic centimeters of pus flowed from the needle. Culture showed hemolytic *Streptococcus*. The wound was closed without further intervention. Subsequently, the patient became conscious and mentally alert. The pulse rose to 80. At 10 P.M. headache returned and the pulse fell to 68. At 5 A.M. the following morning the pulse fell to 50. Blood pressure, 130/80. The patient complained of considerable headache but was not stuporous. A needle was inserted but only 3 cc. of pus were obtained. Although her condition was much improved, it was decided to evacuate and drain the abscess later that morning. At 7:30 A.M. the pulse was 68; blood pressure, 130/70. At 8 A.M. the patient suddenly lost consciousness and respirations ceased. The pulse was 114; blood pressure, 194/150. She was immediately given artificial respiration. An unsuccessful attempt was made to puncture the abscess again. The patient was immediately reoperated upon. The opening in the temporal bone was enlarged. The abscess and a portion of the temporal lobe herniated into the field. They were removed. The pulse fell to 88 but spontaneous respiration was not resumed. She was placed in a respirator but died at 6:30 A.M. the following morning without regaining consciousness. Necropsy revealed that the abscess had been completely removed. There was a very severe cerebral edema and an acute purulent leptomeningitis.

Comment.—Of all our cases, this is the only one in which there is the slightest reason to believe that the delay, consequent to the two stage procedure, may have been responsible for the fatal outcome. Even here there is no assurance, in view of the fulminating course and the presence of an acute purulent meningitis at necropsy, that evacuation and drainage of the abscess at the first operation, less than 48 hours before death, would have produced a more fortunate result.

Usually, however, the patient's condition improves during the interval between the two stages. Forty-eight hours after the initial operation the gauze strip is removed permitting the tissues traumatized by mechanical and chemical means to come together and unite by scar formation. Approximately six days after the initial operation the second stage is undertaken.

Second Stage.—The procedure at the second operation naturally varies somewhat with what has taken place in the interval and with the findings at that time. In the great majority of cases the abscess will still be found beneath the cerebral cortex and will be treated by incision and drainage (Fig. 1 C). In a few instances the abscess will have migrated outward so that the dome protrudes through the defect in the skull (Fig. 1 D). These can

best be treated by marsupialization as advocated by Horrax.⁶ Still more rarely, the abscess will have migrated through the defect in the skull (Fig. 1 E) and can be readily enucleated as recommended by Kahn.⁷

Drainage.—Usually at the second operation the cortex will be found herniated through the defect in the skull. The brain has become firmly sealed to the dura mater about the opening. The overlying cortex is removed either with suction or the high frequency electric cautery, exposing the surface of the abscess. The dome of the abscess is incised. The pus within is removed by suction, care being taken to avoid traumatizing or tearing the capsule. After insertion of ribbon retractors into the abscess, the interior can be investigated for evidence of neighboring communicating abscesses. A firm rubber drain, 1 cm. in diameter, is then inserted into the abscess cavity and held in place by suturing it to the skin. The remainder of the cavity is filled loosely with selvedged gauze which is also brought out and sutured to the skin edge. The skin is then closed about the drain. This method of dealing with the abscess is identical with that advocated by Adson and Craig.¹ The same method is equally adaptable to both cerebral and cerebellar abscesses, and there is little or no danger of contaminating the meningeal spaces, a very real danger in any one stage procedure. Within 24 to 48 hours removal of the gauze strips is begun, part being drawn out and removed each day. After removal of the gauze the rubber drain is released from its anchorage to the skin. It will be forced out gradually as the capsule collapses. The drain is cut off each day as it is extruded. The time and rate of removal of the rubber drain will depend upon the rate of healing of the abscess as determined by the amount of drainage and rate of extrusion of the tube. The following case reports will exemplify the method in a cerebral and in a cerebellar abscess.

Case 11.—Unit No. 168171: I. G., female, age 7, was referred to us by the Children's Memorial Hospital, Chicago, where she had been admitted January 7, 1937. Two weeks previously she had developed an upper respiratory infection which was complicated by an infection in the right ear. On January 9, 1937, a simple right mastoidectomy was performed but no pus was found and she did not improve. Six days later the wound was reexplored and pus was obtained from cells in the zygomatic region. Two days later, January 17, 1937, she developed a severe headache. Examination revealed a bilaterally positive Kernig's sign, a left Babinski's sign and left ankle clonus. That day, the wound was again explored and an extradural abscess found in the region of the squama of the temporal bone and drained. She improved until eight days later, when she developed a severe frontal headache, a left facial weakness and Babinski's sign was again present on the left. The headache persisted. She became stuporous and the pulse dropped from 115 to 60. On January 27, 1937, a lumbar puncture was made. The pressure was 150 Mm. of fluid, the test for globulin was positive; there were 15 white blood cells, nine of which were polymorphonuclear leukocytes. Cultures of the fluid were negative. The patient was first seen by me January 29, 1937, 12 days after the onset of the first intracranial symptoms.

Physical Examination.—The patient was comatose. There was no response except to painful stimuli. There was a marked left facial weakness. The right pupil was

best be treated by marsupialization as advocated by Horrax.⁶ Still more rarely, the abscess will have migrated through the defect in the skull (Fig. 1 E) and can be readily enucleated as recommended by Kahn.⁷

Drainage.—Usually at the second operation the cortex will be found herniated through the defect in the skull. The brain has become firmly sealed to the dura mater about the opening. The overlying cortex is removed either with suction or the high frequency electric cautery, exposing the surface of the abscess. The dome of the abscess is incised. The pus within is removed by suction, care being taken to avoid traumatizing or tearing the capsule. After insertion of ribbon retractors into the abscess, the interior can be investigated for evidence of neighboring communicating abscesses. A firm rubber drain, 1 cm. in diameter, is then inserted into the abscess cavity and held in place by suturing it to the skin. The remainder of the cavity is filled loosely with selvedged gauze which is also brought out and sutured to the skin edge. The skin is then closed about the drain. This method of dealing with the abscess is identical with that advocated by Adson and Craig.¹ The same method is equally adaptable to both cerebral and cerebellar abscesses, and there is little or no danger of contaminating the meningeal spaces, a very real danger in any one stage procedure. Within 24 to 48 hours removal of the gauze strips is begun, part being drawn out and removed each day. After removal of the gauze the rubber drain is released from its anchorage to the skin. It will be forced out gradually as the capsule collapses. The drain is cut off each day as it is extruded. The time and rate of removal of the rubber drain will depend upon the rate of healing of the abscess as determined by the amount of drainage and rate of extrusion of the tube. The following case reports will exemplify the method in a cerebral and in a cerebellar abscess.

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Physical Examination.—The patient was comatose. There was no response except to painful stimuli. There was a marked left facial weakness. The right pupil was

hospital and two months after the onset of the initial infection, complaining of headache.

Physical Examination.—The patient was mentally clear and alert. There was an early bilateral papilledema. The neck was slightly stiff. There were slight incoordination and weakness of the left arm. Blood pressure, 115/80. The examination was otherwise negative. The following day her headache was severe. Pulse had fallen to 52 per minute and she soon became comatose. A slight left facial weakness could be made out.

Operation.—Nine A.M., June 28, 1936: An incision and trephine opening were made in the right temporal region. The opening was enlarged with a rongeur to between 3 and 4 cm. in diameter. A cruciate incision was made in the dura and the brain herniated through the opening. A strip of gauze saturated with a weakened tincture of iodine was packed into the subdural space about the opening. A brain puncture needle was inserted and encountered the abscess at 2 cm. Ten cubic centimeters of pus flowed from the needle. Culture showed hemolytic *Streptococcus*. The wound was closed without further intervention. Subsequently, the patient became conscious and mentally alert. The pulse rose to 80. At 10 P.M. headache returned and the pulse fell to 68. At 5 A.M. the following morning the pulse fell to 50. Blood pressure, 130/80. The patient complained of considerable headache but was not stuporous. A needle was inserted but only 3 cc. of pus were obtained. Although her condition was much improved, it was decided to evacuate and drain the abscess later that morning. At 7:30 A.M. the pulse was 68; blood pressure, 130/70. At 8 A.M. the patient suddenly lost consciousness and respirations ceased. The pulse was 114; blood pressure, 194/150. She was immediately given artificial respiration. An unsuccessful attempt was made to puncture the abscess again. The patient was immediately reoperated upon. The opening in the temporal bone was enlarged. The abscess and a portion of the temporal lobe herniated into the field. They were removed. The pulse fell to 88 but spontaneous respiration was not resumed. She was placed in a respirator but died at 6:30 A.M. the following morning without regaining consciousness. Necropsy revealed that the abscess had been completely removed. There was a very severe cerebral edema and an acute purulent leptomeningitis.

Comment.—Of all our cases, this is the only one in which there is the slightest reason to believe that the delay, consequent to the two stage procedure, may have been responsible for the fatal outcome. Even here there is no assurance, in view of the fulminating course and the presence of an acute purulent meningitis at necropsy, that evacuation and drainage of the abscess at the first operation, less than 48 hours before death, would have produced a more fortunate result.

Usually, however, the patient's condition improves during the interval between the two stages. Forty-eight hours after the initial operation the gauze strip is removed permitting the tissues traumatized by mechanical and chemical means to come together and unite by scar formation. Approximately six days after the initial operation the second stage is undertaken.

Second Stage.—The procedure at the second operation naturally varies somewhat with what has taken place in the interval and with the findings at that time. In the great majority of cases the abscess will still be found beneath the cerebral cortex and will be treated by incision and drainage (Fig. 1 C). In a few instances the abscess will have migrated outward so that the dome protrudes through the defect in the skull (Fig. 1 D). These can

twice the size of the left. The tendon reflexes were active and equal. Babinski's sign was positive on the left. The optic disks were flat and normal. *Diagnosis:* Abscess of the right temporal lobe and, although it was thought probably to be a futile procedure, an operation was undertaken.

Operation.—January 29, 1937: The first stage was carried out as outlined above. The subdural space was packed off. A needle was inserted. It encountered the abscess at 2 cm., and 45 cc. of dirty, reddish purulent material flowed out. Culture showed a hemolytic *Streptococcus*. The wound was closed.

At the beginning of the operation she was comatose, pulse, 60. At the close she was fully conscious and the pulse was 80. Two days later, January 31, 1937, the gauze was withdrawn from the subdural space. Her temperature, pulse and respirations were normal and remained so thereafter. Examination revealed only a left homonymous, upper quadrantic defect in the visual fields and a slight left facial weakness. On February 6, 1937, she complained of a slight frontal headache and 28 cc. of pus were aspirated. The following day 20 cc. more were removed.

Second Stage.—February 8, 1937, ten days after the first stage: The previous incision was reopened. The abscess was now only 1 cm. beneath the surface. The abscess was treated exactly as described above. For the next three days the drainage was profuse. By February 16, 1937, eight days after drainage of the abscess, the gauze pack had been removed and the amount of purulent drainage was considerably reduced. Four days later the suture restraining the rubber tube was cut and the tube was gradually extruded, and was entirely removed March 13, 1937, 33 days after drainage of the abscess. The wound was healed by March 24, 1937, and she was discharged from the hospital perfectly well two days later, exactly eight weeks after admission. She was last seen April 25, 1938, at which time she was perfectly well. Neurologic examination was entirely negative and the visual fields were full.

Comment.—In addition to strengthening our faith in this method of treatment, this case has made us wary of despairing of any case of brain abscess until all possible therapeutic measures have been exhausted.

Exactly the same procedure is equally suitable for the treatment of abscesses of the cerebellum as illustrated by the following case.

Case 15.—Unit No. 50693: D. Y., male, age 7, was referred by the Children's Memorial Hospital, Chicago. In the autumn of 1934, he developed pneumonia which was followed by a left otitis media. In February, 1935, an attack of scarlet fever resulted in a reactivation of the otitis media. On March 27, 1935, he developed a frontal headache, continuous vomiting, and as a result rapidly lost weight. He was admitted to the Children's Memorial Hospital two days later. At that time he was alternately irritable and stuporous. There was a slight rigidity of the neck. A lumbar puncture was made. The pressure was "normal." There were 480 white blood cells, 60 per cent lymphocytes. Cultures were negative. There were 56 mg. of glucose per 100 cc. He developed a right sixth and seventh cranial nerve weakness, a mild left hemiparesis and became stuporous. Two days later a left external rectus weakness developed. Subsequently his condition improved. Roentgenograms made on April 24, 1935, revealed a slight separation of the cranial sutures. On May 10, 1935, an early papilledema was observed. Eight days later he was admitted to the University of Chicago Clinics.

Physical Examination.—There was no spontaneous voluntary movement of the left arm or leg but they were not paralyzed. There was gross incoordination of the left arm and leg with marked flaccidity of those extremities. The gait could not be tested. The optic disks were choked. Ocular movements were full but there was a slow, coarse nystagmus on looking to the left. The tendon reflexes were uniformly diminished.

Babinski's sign was not present. The neck was moderately stiff. Kernig's sign was not present. *Diagnosis:* Abscess of the left cerebellar hemisphere.

First Stage.—May 23, 1935: The usual incision and small craniectomy were made over the left cerebellar hemisphere. The subdural space was packed about the opening and the wound closed. Two days later he was in excellent condition. The subdural pack was removed.

Second Stage.—May 28, 1935: The former incision was reopened. The abscess was found 0.5 cm. below the surface. It was opened, evacuated and a firm rubber drain inserted as described above. Smears of the pus revealed Streptococci.

Following the operation there was moderate drainage. On June 2, 1935, the suture holding the drain in place was cut and the drain was slowly extruded. It was completely removed June 12, 1935. By June 18, 1935, the wound was healed and the patient was able to walk unaided. He was discharged June 30, 1935, 38 days after the first operation.

When last seen, September 15, 1937, two years and four months after the operation, the boy was perfectly well. There was no evidence of any cerebellar disturbance.

Marsupialization.—Occasionally when the wound is reopened at the second operation, the dome of the abscess will be found to have herniated through the defect in the bone (Fig. 1 D). In such cases, the abscess can be opened, evacuated and the capsule sutured to the subcutaneous tissue or scalp, thus marsupializing it as recommended by Horrax.⁶ The abscess is then drained and packed as previously described. In the following case this method was used.

Case 17.—Unit No. 169671: D. H., male, age 14, was referred by Dr. Raymond Brown of Joliet, Illinois. In November, 1936, he developed an upper respiratory infection. The following month a right otitis media appeared. One week later, December 26, 1936, he developed a severe headache, complained of dizziness and then gradually grew worse. On January 8, 1937, a right mastoidectomy was performed. Although his general condition improved, it was soon noted that the right arm and leg were unsteady. On February 12, 1937, he developed a very severe headache and the following day projectile vomiting appeared. He was admitted to the University of Chicago Clinics February 19, 1937. He was an intelligent cooperative patient. He was and for years had been excessively obese. There was a bilateral papilledema of two diopters. The visual fields were full. Upward conjugate deviation of the eyes was poorly done. There was a nystagmus on looking to either side, more marked to the right, and on looking upward. The right upper and lower extremities were hypotonic and their movements were very ataxic. There was marked dysdiadokokinesis on the right side. He was unable to stand with his feet together and swayed when he stood with his feet wide apart. He staggered when he walked, falling mostly to the *left*. The neck was stiff. The tendon reflexes were more active on the right. There was a sustained ankle clonus on the right, unsustained on the left side. Babinski's sign was present on the right. The temperature and respirations were normal; pulse, 100. *Diagnosis:* Right-sided cerebellar abscess.

Operation.—First Stage. February 20, 1937: A vertical incision and an opening in the occipital bone were made over the right cerebellar hemisphere. The subdural space was packed. A needle was inserted which encountered the abscess at 1 cm.; 45 cc. of greenish white pus flowed out. The organism proved to be a pneumococcus, Type II.

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Physical Examination.—There was no spontaneous voluntary movement of the left arm or leg but they were not paralyzed. There was gross incoordination of the left arm and leg with marked flaccidity of those extremities. The gait could not be tested. The optic disks were choked. Ocular movements were full but there was a slow, coarse nystagmus on looking to the left. The tendon reflexes were uniformly diminished.

The subdural pack was removed in 48 hours, and six days after the first operation the second stage was undertaken.

Second Stage.—February 26, 1937: The old incision was reopened. The dome of the abscess had herniated through the opening in the bone. It was incised and the capsule sutured to the subcutaneous tissue. The pus within the abscess was evacuated and a firm rubber tube drain inserted.

Two days later, he developed a diplopia and a weakness of the right external rectus muscle which persisted until his discharge from the hospital. The wound did not drain well. On March 7, 1937, nine days after drainage was instituted, the wound became tense and two days later began discharging cerebrospinal fluid. The patient was placed flat in bed and fluids were forced. The drainage of cerebrospinal fluid was profuse. On March 11, 1937, the signs of right cerebellar involvement returned but began to subside about six days later. By March 24, 1937, the amount of cerebrospinal fluid drainage had become reduced and four days later it ceased, but herniation of the wound appeared and grew progressively more marked. On April 3, 1937, the wound was reopened. No abscess was found and the cerebellar hernia was amputated. The wound was drained and subsequently discharged cerebrospinal fluid which on culture was found to contain hemolytic *Staphylococcus aureus*. On April 19, 1937, the optic disks were flat. The patient had no headache. There was a marked nystagmus on looking to the right and severe right-sided signs of cerebellar deficit. By April 27, 1937, all drainage of cerebrospinal fluid had ceased and the patient was up in a chair. A slight purulent discharge persisted. On May 13, 1937, a small bony sequestrum was removed. By June 9, 1937, the wound was completely healed and the patient was discharged. He was able to walk, but rather severe cerebellar signs still persisted. When seen November 8, 1937, he had gained 15½ pounds in weight since leaving the hospital and weighed 221½ pounds. His station and gait were good. He could stand with his feet together without swaying. There was still considerable dysdiadokokinesis of the right hand, and his writing, though legible, was poor. The wound was well healed, bulging slightly. The optic disks were flat. He was placed on a limited diet and within a month lost 23½ pounds. He is feeling well and the remaining cerebellar signs are rapidly diminishing.

Comment.—In addition to illustrating the utilization of the marsupialization technic, which is limited in its usefulness to a very small group of cases, this case illustrates the method of dealing with a leak of cerebrospinal fluid employed in this clinic. This is a point which will be dealt with in more detail later.

Enucleation.—Like many other neurosurgeons, we have had the experience of enucleating an encapsulated abscess under the mistaken impression that we were dealing with a tumor. Case 1 was an instance in point. It needs no further discussion. Vincent's⁸ technic of repeated aspiration of an abscess until it develops a thick capsule and then deliberately reflecting an osteoplastic flap and enucleating the abscess as one would a tumor appeals to us as a rational method of treatment. It is most suitable for abscesses in the frontal lobes. We have had no opportunity to use exactly this technic since we learned of it but the following case is not dissimilar.

Case 10.—Unit No. 156653: M. G., female, age 3, was referred by Dr. Frank Greer, Chicago. About July 10, 1936, she developed a sty on the left eyelid. On July 12, 1936, she fell out of bed striking the region of the left eye. The following day she developed a fever of 102° F. which persisted for several days. On July 16,

1936, a tender swelling appeared in the left temple and the eye was swollen shut. On July 20, 1936, the temporal swelling was incised and pus and blood evacuated. The edema of the eyelids subsided and she was found to have a strabismus. The temporal abscess soon reformed and she was admitted to the University of Chicago Clinics July 29, 1936.

Physical Examination revealed no neurologic or other abnormalities other than the tender fluctuant swelling in the left temporal region. Roentgenograms of the skull were considered normal except for a questionable erosion of the lateral margin of the left orbit. The temporal region was incised and a large abscess found beneath the temporal muscle, which was drained. Cultures of the pus revealed hemolytic *Staphylococcus aureus*. The wound soon healed and the patient was discharged August 26, 1936. On September 3, 1936, she developed nausea and vomiting and was readmitted to the Clinics. Examination revealed a small swelling in the left frontal region just at the hairline. Neurologic and ophthalmoscopic examinations revealed no abnormalities. Roentgenograms of the skull showed a small area of osteomyelitis present beneath the swelling. On reviewing the roentgenograms, made during her previous hospitalization, it was obvious that this area of osteomyelitis, though much smaller, had been present at that time and had been overlooked. The area of osteomyelitis was extirpated and the wound packed. There was no extradural abscess and the dura mater was under no unusual tension. The same organism was cultured. Seven days later, September 15, 1936, she complained of headache and vomited. Examination revealed early papilledema, a diminution in voluntary use of the left arm and leg, a left facial weakness, diminution of the tendon reflexes on the left side with a left Babinski sign. Sensation was intact. *Diagnosis*: Brain abscess in the right precentral region (*i.e.*, contralateral to the original infection).

Operation.—First Stage. September 16, 1936: The right precentral region was exposed, the subdural space packed. A brain puncture needle was inserted and an abscess encountered at 6 cm. Thirty cubic centimeters of pus were evacuated. Culture revealed hemolytic *Staphylococcus aureus*.

The following day the patient was much better but symptoms of refilling of the abscess soon appeared. Four days after the first stage operation and evacuation of the abscess, a needle was inserted through the wound into the abscess. Pus flowed out, only to be followed shortly by cerebrospinal fluid. This we interpreted as due to rupture of the lateral ventricle into the abscess. At this depth (6 cm.) the ventricle presumably lay immediately beneath the abscess. The original needle was replaced by a slightly shorter needle of the T-shaped type designed by Frazier. Within two days the drainage of cerebrospinal fluid ceased and the needle was withdrawn. Her condition continued to improve and it was hoped that repeated aspiration of this deep-seated abscess would suffice, but not so. On October 29, 1936, about one and one-half months after the original aspiration, the wound began to herniate. The abscess was punctured and evacuated repeatedly. The abscess was encountered more and more superficially. On November 17, 1936, the wound was reopened and the opening in the bone enlarged. The subdural space was, therefore, again packed off. A needle encountered the abscess at 3 cm. and 25 cc. of pus were removed.

Drainage.—Seven days later, November 24, 1936, the wound was again reopened. The brain tissue overlying the abscess was removed with the Bovie high frequency current. The abscess was opened and evacuated, and beneath it was found a second abscess which communicated with the uppermost by a narrow neck. It, too, was opened, a firm rubber drain inserted, and the cavities packed as previously described.

The packing was removed by December 2, 1936, and the rubber tube by December 21, 1936. The wound soon healed and was depressed. But by January 17, 1937, it was bulging again. Two days later 25 cc. of pus were aspirated. On January 22, 1937, 15 cc.

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The following day the patient was much better but symptoms of refilling of the abscess soon appeared. Four days after the first stage operation and evacuation of the abscess, a needle was inserted through the wound into the abscess. Pus flowed out, only to be followed shortly by cerebrospinal fluid. This we interpreted as due to rupture of the lateral ventricle into the abscess. At this depth (6 cm.) the ventricle presumably lay immediately beneath the abscess. The original needle was replaced by a slightly shorter needle of the T-shaped type designed by Frazier. Within two days the drainage of cerebrospinal fluid ceased and the needle was withdrawn. Her condition continued to improve and it was hoped that repeated aspiration of this deep-seated abscess would suffice, but not so. On October 29, 1936, about one and one-half months after the original aspiration, the wound began to herniate. The abscess was punctured and evacuated repeatedly. The abscess was encountered more and more superficially. On November 17, 1936, the wound was reopened and the opening in the bone enlarged. The subdural space was, therefore, again packed off. A needle encountered the abscess at 3 cm. and 25 cc. of pus were removed.

Drainage.—Seven days later, November 24, 1936, the wound was again reopened. The brain tissue overlying the abscess was removed with the Bovie high frequency current. The abscess was opened and evacuated, and beneath it was found a second abscess which communicated with the uppermost by a narrow neck. It, too, was opened, a firm rubber drain inserted, and the cavities packed as previously described.

The packing was removed by December 2, 1936, and the rubber tube by December 21, 1936. The wound soon healed and was depressed. But by January 17, 1937, it was bulging again. Two days later 25 cc. of pus were aspirated. On January 22, 1937, 15 cc.

The subdural pack was removed in 48 hours, and six days after the first operation the second stage was undertaken.

Second Stage.—February 26, 1937: The old incision was reopened. The dome of the abscess had herniated through the opening in the bone. It was incised and the capsule sutured to the subcutaneous tissue. The pus within the abscess was evacuated and a firm rubber tube drain inserted.

Two days later, he developed a diplopia and a weakness of the right external rectus muscle which persisted until his discharge from the hospital. The wound did not drain well. On March 7, 1937, nine days after drainage was instituted, the wound became tense and two days later began discharging cerebrospinal fluid. The patient was placed flat in bed and fluids were forced. The drainage of cerebrospinal fluid was profuse. On March 11, 1937, the signs of right cerebellar involvement returned but began to subside about six days later. By March 24, 1937, the amount of cerebrospinal fluid drainage had become reduced and four days later it ceased, but herniation of the wound appeared and grew progressively more marked. On April 3, 1937, the wound was reopened. No abscess was found and the cerebellar hernia was amputated. The wound was drained and subsequently discharged cerebrospinal fluid which on culture was found to contain hemolytic *Staphylococcus aureus*. On April 19, 1937, the optic disks were flat. The patient had no headache. There was a marked nystagmus on looking to the right and severe right-sided signs of cerebellar deficit. By April 27, 1937, all drainage of cerebrospinal fluid had ceased and the patient was up in a chair. A slight purulent discharge persisted. On May 13, 1937, a small bony sequestrum was removed. By June 9, 1937, the wound was completely healed and the patient was discharged. He was able to walk, but rather severe cerebellar signs still persisted. When seen November 8, 1937, he had gained 15½ pounds in weight since leaving the hospital and weighed 221½ pounds. His station and gait were good. He could stand with his feet together without swaying. There was still considerable dysdiadokokinesis of the right hand, and his writing, though legible, was poor. The wound was well healed, bulging slightly. The optic disks were flat. He was placed on a limited diet and within a month lost 23½ pounds. He is feeling well and the remaining cerebellar signs are rapidly diminishing.

Comment.—In addition to illustrating the utilization of the marsupialization technic, which is limited in its usefulness to a very small group of cases, this case illustrates the method of dealing with a leak of cerebrospinal fluid employed in this clinic. This is a point which will be dealt with in more detail later.

Enucleation.—Like many other neurosurgeons, we have had the experience of enucleating an encapsulated abscess under the mistaken impression that we were dealing with a tumor. Case I was an instance in point. It needs no further discussion. Vincent's⁸ technic of repeated aspiration of an abscess until it develops a thick capsule and then deliberately reflecting an osteoplastic flap and enucleating the abscess as one would a tumor appeals to us as a rational method of treatment. It is most suitable for abscesses in the frontal lobes. We have had no opportunity to use exactly this technic since we learned of it but the following case is not dissimilar.

Case 10.—Unit No. 156653: M. G., female, age 3, was referred by Dr. Frank Greer, Chicago. About July 10, 1936, she developed a sty on the left eyelid. On July 12, 1936, she fell out of bed striking the region of the left eye. The following day she developed a fever of 102° F. which persisted for several days. On July 16,

were removed. January 23, 1937, the wound was again opened. The abscesses were found, evacuated and drained. On February 10, 1937, the drain was finally removed. The wound soon healed and the patient was discharged from the hospital February 14, 1937.

On February 25, 1937, she fell from a chair and struck her head. The next day she developed a headache, vomited and had a temperature of 101.2° F. She was readmitted on February 27, 1937. The wound was bulging and discharging some pus. She had a left hemiparesis which has been present almost from the outset. Thirty cubic centimeters of pus were aspirated but the wound soon filled out again.

Enucleation.—March 6, 1937: An osteoplastic flap was reflected. The abscess was carefully dissected free from the surrounding brain but in the inferior part the wall was very thin and ruptured. The ventricle was opened. The wound was drained through the center of the scalp flap, the bone being discarded. Cultures revealed the same organism, namely, hemolytic *Staphylococcus aureus*.

The patient was kept flat in bed. Fluids were forced. A profuse drainage of cerebrospinal fluid continued for two weeks. By April 12, 1937, the wound was entirely healed and has remained so. The child has a severe left hemiparesis but is otherwise well. There have been no further symptoms of recurrence of the abscess.

Comment.—In this case both repeated aspiration and drainage failed to cure the abscess. Enucleation was finally undertaken more or less in despair. The results were sudden and excellent. It is unfortunate that the right central region and internal capsule were involved but no method of treatment could have altered this or the appearance of the hemiparesis. This case again illustrates the development and treatment of a leak of cerebrospinal fluid.

Recently, Kahn⁷ has advocated a two stage procedure, at the second stage of which the tumor is enucleated. Kahn's first stage is similar to that described in this paper except that Kahn does not advocate puncturing the abscess—a procedure which, in this clinic, has been found at times to be of great value in reducing the intracranial tension and tiding the patient over to the second stage. At the second stage Kahn has occasionally found the abscess extruded out of the skull. When this occurs, as illustrated by Case 8, abstracted below, the abscess is readily removed (Fig. 1 E). Usually, however, although the abscess will be found to have migrated nearer the surface, it will still be beneath the level of the skull. In such instances Kahn removes the overlying brain tissue by suction, incises and evacuates the abscess and then removes the capsule by dissecting it free from the surrounding brain tissue. It is obvious that removal of an extruded brain abscess *in toto*, when possible, is a highly satisfactory method of treatment. Dissecting the capsule free from the surrounding traumatized and edematous brain tissue after the field has been contaminated by incising and evacuating the abscess is not, however, as free from danger and not a procedure that we have felt justified in employing. The following case illustrates the possibility of removing an abscess after it has been extruded from the skull although the course followed is not identical with that outlined by Kahn.

Case 8.—Unit No. 40528: C. B., male, age 19, had been treated in this clinic, where he had been referred by Stanley H. Skrentney, Hammond, Indiana, in June, 1931, because of multiple areas of osteomyelitis. He had suffered from convulsive seizures for years.

About July 15, 1935, he developed an abscess beneath the scalp in the left parietal region. He was admitted to the hospital October 2, 1935, because of this swelling, difficulty in talking and numbness of the right hand. Roentgenograms, revealed an area of osteomyelitis in the left parietal bone.

Physical Examination.—The patient had a definite aphasia, the optic disks were not quite clear but were not choked. Sensation was slightly reduced on the right side. The knee and ankle jerks were more active on the right. Babinski's sign was present bilaterally. There was a sustained ankle clonus on the right, unsustained on the left.

Operation.—October 3, 1935: The subaponeurotic abscess was evacuated; the area of osteomyelitis measuring 5x6 cm. was removed and an extradural abscess 1.5 cm. deep at its thickest point evacuated and drained. The infecting organism was *Staphylococcus aureus*.

He rapidly improved thereafter and was discharged October 19, 1935, returning to the outpatient department for dressings. On November 6, 1935, he had a jacksonian convulsive attack involving the right hand. The wound was healed by December 27, 1935. He was quite well until the latter part of January, 1936, when he began to suffer from headaches. On February 26, 1936, the wound was bulging and tense and there was bilateral papilledema of two diopters. He was again admitted to the hospital. There was a slight right facial weakness, the right arm was weak and its movement slow and poorly coordinated. Sensation was slightly reduced on the right. Reflexes in the right lower extremity were increased and Babinski's sign was present.

Operation.—February 28, 1936: The old incision was reopened. There was no extradural collection of pus. The dura mater was incised. The brain was brown and gelatinous and adherent to the dura. A needle encountered an abscess a few millimeters below the surface. Subsequent events showed that the abscess should have been enucleated, a procedure which would have been relatively simple. However, because of its location it was incised, evacuated and drained in the hope of causing less neurologic disturbance. There was only moderate drainage. On March 6, 1936, the wound began to bulge. By March 8, 1936, his speech had become worse.

Enucleation.—On March 11, 1936, the herniation having become more marked, the wound was reopened. The abscess had herniated out of the skull and was readily removed.

By March 24, 1936, the brain was again herniating, and the patient had become completely aphasic. On April 1, 1936, he had a large infected fungus. Three days later this was amputated with the Bovie electrosurgical unit. A fistula draining cerebrospinal fluid resulted. The patient was placed flat in bed and fluids were forced. The drainage of cerebrospinal fluid continued until April 28, 1936. The wound was healed by June 7, 1936. He has continued well except for a severe right hemiparesis and a partial aphasia.

Comment.—The unfortunate permanent result obtained in this case, of a hemiplegia and a partial aphasia, was because of the location of the abscess and is in no way attributable to the method of treatment. Undoubtedly the whole course could have been materially shortened by enucleating the abscess when it was first exposed. That was accomplished in Case 4, where a small abscess, about 3 cm. in diameter, was found just beneath the dura and an area of osteomyelitis in the temporal bone.

Repeated Aspiration.—Dandy² has recommended that abscess of the brain be treated simply by aspiration. He states that one aspiration may suffice or that occasionally one, two or three additional tapings may be necessary. Our own experience with this method has not impressed us with its efficacy. In one instance previously cited, Case 10, many more aspirations than four

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Case 6.—Unit No. 90999: J. A. M., male, age 26, was struck over the head with a lead pipe September 27, 1933. He sustained a compound, comminuted, depressed fracture in the upper right central region. He was admitted to the University of Chicago Clinics about 12 hours after the injury. His left arm was completely paralyzed; the arm was flaccid. There was a left lower facial weakness. The tendon reflexes were diminished in the left arm. He was operated upon immediately. The fragments of bone were removed. One had been driven through the dura. The wound was thoroughly débrided and closed. On October 2, 1933, five days later, purulent drainage (hemolytic *Streptococcus*) appeared. The strength of the arm was improving. The following day the left leg became weak and Babinski's sign was present. On October 10, 1933, a localized subaponeurotic abscess was drained. On October 21, 1933, he had some headache and a moderately stiff neck. The scalp wound was opened more extensively and in doing so the dura was unintentionally nicked. The cortex protruded through this opening. A needle was inserted and at 2 cm. encountered an abscess from which several drops of thick pus were obtained. Culture showed hemolytic *Streptococcus*. Only the scalp wound was drained. He soon began to recover and was discharged on November 24, 1933. He has an almost completely paralyzed left arm and walks with a hemiplegic gait, but there have been no signs of progression of his abscess and he has been seen frequently during the years since his accident.

Comment.—It seems very questionable whether the aspiration of a few drops of pus from this small abscess played any part in its cure but there was no other specific treatment to which credit could be given.

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When to Operate.—The neurosurgeon has always been greatly concerned about when to operate upon an abscess of the brain. It is generally agreed that operations upon well encapsulated abscesses will be more successful, and that encapsulation requires about four to six weeks. In many instances, however, the patient's condition will not permit of such prolonged delay. An

TABLE

SYNOPSIS OF STATISTICAL DATA RELEVANT

Case No.	Name	Unit No.	Sex	Age	Date of Onset of Original Infection	Date of Onset of Abscess	Date of First Operation	Date of Discharge	Origin
CERE-									
1	W. J. G.	11789	M.	15 yrs.	11-17-28	12-18-28	5-14-29	6- 7-29	Right ear
2	L. K.	19702	F.	37 yrs.	10-15-29	11-14-29	2-13-30	2-22-30	Multiple infections;
3	J. P.	35919	M.	18 mos.	8-22-30	11- 5-30	11-25-30	12- 5-30	+ bloodculture Empyema
						(?)		Died	
4	W. R.	51849	M.	61 yrs.	4- ?-31	6- ?-31	12-28-31	3- 8-32	Osteomyelitis right fibula and skull
5	R. M. K.	64749	F.	3 yrs.	3- ?-31	7-10-32	7-28-32	7-29-32	Empyema; bron-
6	J. A. M.	90999	M.	26 yrs.	9-27-33	(?)	10-21-33	11-24-33	chiectasis
7	M. O.	106530	F.	7 yrs.	?	3-14-34	6-28-34	8- 4-34	Compound skull fracture
8	C. B.	40528	M.	19 yrs.	7-15-35	?	2-28-36	6- 7-36	Osteomyelitis of skull
9	V. D.	154484	F.	15 yrs.	4-27-36	?	6-28-36	6-30-36	Right ear
								Died	
10	M. G.	156653	F.	3 yrs.	7-10-36	9- 3-36	9-16-36	4-12-37	Osteomyelitis of skull
11	I. G.	168171	F.	7 yrs.	12-25-36	1-17-37	1-29-37	3-26-37	Right ear
12	T. S.	178470	M.	10 yrs.	6-20-37	6-22-37	8-10-37	9-16-37	Right ear
13	N. A. C.	191568	F.	6 yrs.	11- 1-37	11- 1-37	1-24-38	2-10-38	Ran stick up nose into brain
								Died	
CERE-									
14	B. S.	50693	F.	11 mos.	1-26-31	3- 1-31	12- 2-31	2- 3-32	Pneumonia
15	D. Y.	128349	M.	7 yrs.	Autumn 1934	3-27-35	5-23-35	6-30-35	Left ear
16	G. C.	153198	F.	4 yrs.	5- ?-35	5-31-36	6-12-36	4- 5-37	Bilateral mastoid-
17	D. H.	169671	M.	14 yrs.	12-19-36	12-26-36	2-20-37	6- 9-37	itis Right ear

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BRAIN ABSCESS

I
TO 17 CASES OF ABSCESS OF THE BRAIN

Organism	Location	Treatment	Cerebro-spinal Fluid Leak	Result	Remarks
BRAL					
?	Right temporal	1 stage; enucleation	o	Recovered	Blind before operation
<i>Staph. aureus</i>	Right parietal	1 stage; drainage	o	Died	No necropsy
Chest: Strep. Brain abscess: No growth	Right parietal	1 stage; drainage	o	Died	Necropsy: Multiple (7) abscesses right cerebral hemisphere; meningitis
<i>Staph. aureus</i>	Right temporal	1 stage; enucleation	o	Recovered	Died several months later; cerebrovascular accident (?)
Strep.	Left occipitoparietal	1 stage; drainage	o	Died	Ruptured into ventricle before operation
<i>Strep. hemol.</i>	Right central	Single aspiration	o	Recovered	Left hemiparesis; convulsions
<i>Strep. hemol.</i>	Right central	1 stage; drainage	o	Recovered	Left hemiparesis; jacksonian convulsions
<i>Staph. aureus</i>	Left central	1 stage; drainage, later enucleation	+	Recovered	Right hemiparesis; partial aphasia; convulsions years before abscess
<i>Strep. hemol.</i>	Right temporal	2 stage; drainage	o	Died	Necropsy: Abscess removed at second operation; severe edema; meningitis
<i>Staph. aureus</i>	Right central	2 stage; repeated aspiration; drainage; enucleation	+	Recovered	Left hemiparesis
<i>Strep. hemol.</i>	Right temporal	2 stage; drainage	o	Recovered	No sequelae
<i>Strep. hemol.</i>	Right temporal	1 stage; drainage	+	Recovered	No sequelae
<i>Staph. aureus</i> , pneumococcus Type XXIV	Right frontal	2 stage; drainage	o	Died	Necropsy: Stick found protruding through cribriform plate. Basilar meningitis spread from this point.
BELLAR					
Sterile	Vermis and right hemisphere	1 stage; drainage	+	Recovered	Impaired vision; retarded growth; obese
Smear: Strep., culture negative	Left hemisphere	2 stage; drainage	o	Recovered	No sequelae
<i>Strep. hemol.</i>	Right hemisphere	2 stage; drainage	+	Recovered	Slight cerebellar deficit
Pneumococcus Type II	Right hemisphere	2 stage; drainage	+	Recovered	Slight cerebellar deficit

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operation postponed too long may result, if not in death, in blindness (*e.g.*, Cases 1 and 14). As near as it has been possible to estimate, the period from the onset of the cerebral infection until operation has varied in our cases from 12 days to nine months. In the instance of shortest duration, Case 11, previously cited, the short duration of the abscess infected with hemolytic Streptococci cannot be said to have in any way interfered with obtaining an excellent result as this is one of the most striking cases in this series. This patient, whose original infection (otitis media) had occurred only one month previously, and whose first symptom of invasion of the nervous system appeared only 12 days before admission, was brought into the hospital comatose. She was operated upon by the two stage procedure herein outlined, and was discharged from the hospital completely recovered less than two months later.

The majority of abscesses had best be attacked as soon as the diagnosis has been made with reasonable certainty. In a few cases, where conditions will permit, a short delay, with the patient under close observation may be desirable in order to afford more time to allow of better encapsulation. Unfortunately cases where this is possible are all too rare. Nor is such delay entirely without danger. Rupture of the abscess into the ventricle (Case 5), the development of a meningitis, or of a severe and fatal cerebral edema (Case 9), are possibilities.

SUMMARY

Seventeen consecutive cases of abscess of the brain treated by surgical means are reported. Twelve of these (70.6 per cent) recovered. Five (29.4 per cent) died. In three of these fatal cases the abscess arose from the lung. In one case, multiple abscesses of the brain were found at necropsy; in another, multiple areas of infection, including the blood stream, were present throughout the body and multiple brain abscesses were suspected; in a third, the abscess had ruptured into the ventricle prior to operation. In the fourth case, the abscess arose from the ear and was located in the temporal lobe; it was a particularly fulminating case and the patient died soon after the first stage. Necropsy revealed that the abscess had been removed at an emergency second operation and that a leptomeningitis was present. In the fifth case, an abscess of the right frontal lobe developed as the result of the penetration of a stick through the cribriform plate into the brain. After drainage of the abscess and relief of the pressure, a basilar meningitis spread backward from the region of the cribriform plate, causing death.

A method of surgical procedure is outlined. It is designed to prevent meningitis by contamination of the meningeal spaces. It consists of two stages. At the first stage, a small craniectomy is made, the subdural space is packed off with gauze soaked in a weak solution of iodine, and the abscess may or may not be punctured and partially evacuated. The gauze is removed 48 hours later. At the second stage, some six days after the first,

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TO 17 CASES OF ABSCESS OF THE BRAIN

Organism	Location	Treatment	Cerebro-spinal Fluid Leak	Result	Remarks
<i>BRAL</i>					
?	Right temporal	1 stage; enucleation	o	Recovered	Blind before operation
<i>Staph. aureus</i>	Right parietal	1 stage; drainage	o	Died	No necropsy
Chest: Strep. Brain abscess: No growth	Right parietal	1 stage; drainage	o	Died	Necropsy: Multiple (7) abscesses right cerebral hemisphere; meningitis
<i>Staph. aureus</i>	Right temporal	1 stage; enucleation	o	Recovered	Died several months later; cerebrovascular accident (?)
Strep.	Left occipitoparietal	1 stage; drainage	o	Died	Ruptured into ventricle before operation
<i>Strep. hemol.</i>	Right central	Single aspiration	o	Recovered	Left hemiparesis; convulsions
<i>Strep. hemol.</i>	Right central	1 stage; drainage	o	Recovered	Left hemiparesis; jacksonian convulsions
<i>Staph. aureus</i>	Left central	1 stage; drainage, later enucleation	+	Recovered	Right hemiparesis; partial aphasia; convulsions years before abscess
<i>Strep. hemol.</i>	Right temporal	2 stage; drainage	o	Died	Necropsy: Abscess removed at second operation; severe edema; meningitis
<i>Staph. aureus</i>	Right central	2 stage; repeated aspiration; drainage; enucleation	+	Recovered	Left hemiparesis
<i>Strep. hemol.</i>	Right temporal	2 stage; drainage	o	Recovered	No sequelae
<i>Strep. hemol.</i>	Right temporal	1 stage; drainage	+	Recovered	No sequelae
<i>Staph. aureus</i> , pneumococcus Type XXIV	Right frontal	2 stage; drainage	o	Died	Necropsy: Stick found protruding through cribriform plate. Basilar meningitis spread from this point.
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Pneumococcus Type II	Right hemisphere	2 stage; drainage	+	Recovered	Slight cerebellar deficit

the abscess will be found to have migrated nearer the surface. The overlying brain tissue is removed and the abscess is evacuated and drained.

In addition, the questions of enucleation of the abscess, of treatment by repeated aspiration, the problems of dealing with leaks of cerebrospinal fluid, and of when to operate are discussed.

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CARCINOMATOUS METASTASES TO THE BRAIN

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THE treatment of carcinomatous metastases to the brain is a subject which is unlikely to arouse much general interest because of the hopeless outlook from a curative standpoint. However, on the same basis, the ultimate prognosis is almost equally discouraging in infiltrative gliomata (glioblastoma multiforme). In fact, all types of palliative surgery for malignancy fall into this category, in which an eventual mortality is inevitable.

With the realization that curative therapy is impossible, it becomes necessary to seek other criteria upon which to base the advisability or inadvisability of surgical intervention. Obviously, the simplicity or multiplicity of the intracranial lesion is of primary importance. The present report is based entirely upon cases in which the metastasis appeared to be solitary. As in other forms of palliative surgery, three other factors must be considered: (1) The relief of symptoms; (2) duration of life; and (3) the operative mortality. The present cases are analyzed in regard to these three factors.

Grant,¹ in 1926, compared the results in 25 cases, in whom some form of intracranial operation was performed, with those in 22 cases who were not operated upon. He stated: "The average length of life from time of admission to this hospital to death in both verified and unverified cases, whether operated or non-operated, whether radical extirpation or palliative decompression was performed, was less than four months." There is no doubt that these discouraging results have strongly tempered the opinion of the profession regarding surgical intervention in cases of malignant intracranial metastases. However, one conclusion of Grant's is often overlooked. After stating that surgery is unable to prolong the life of these patients, he added: "But surgical intervention for the relief of intracranial pressure is frequently indicated and may go far toward relieving suffering in the last few months of life."

Shelden,² in 1926, reviewed 40 cases of secondary tumors of the brain, from the aspect of diagnosis. Although his paper was not primarily concerned with surgical indications, he distinctly intimated that surgical intervention was not advisable. This passive attitude toward the problem was challenged by Oldberg,³ in 1933. He reported three cases of metastatic cerebral lesions with survival periods of eight months, two years and three years. As further evidence in support of operative intervention, he cited a case of a cervical cord meningioma, wrongly diagnosed as metastatic carcinoma because of previous malignancy. Fortunately, the patient was operated upon and the benign tumor removed. This is a striking example of the fact that